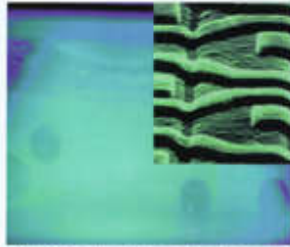


DPP Education Outreach

The Pervasive Plasma State

open



PLASMA STRUCTURE. A used to describe high-density magnetic fields. A magnetic field of the order of 10 T is shown in the upper right.

can cause serious problems for plasma applications in other settings. When high-energy particles burst from hot fusion plasmas, they can knock cold particles loose from the container's walls, quenching and contaminating the plasma within.



ELECTRON-CYCLOTRON RESONANCE (ECR) systems are used to heat fusion devices and plasma waste. Plasma control at the magnetic field is achieved by varying the parameters of the plasma. (Courtesy of Engineering Research Center for Plasma and Nanotechnology, University of Minnesota, Minneapolis, December 1998)



PLASMA TORCH. TORCHES are used to deposit thermal layers from a plasma source. (Courtesy of General Electric Co., Northampton, Massachusetts)

UNDERSTANDING PLASMAS

Collective effects become still more interesting when the subject is waves in plasmas. In this respect, a neutral gas is a bit of a one-trick pony, supporting only sound waves, which arise out of a tension competition between the neutral atoms' pressure and their inertia when the gas is jostled at the right frequency. Such a sound wave eventually dies away as collisions between atoms turn its coherent motions into random, thermal energy in the gas.

By contrast, a plasma supports a multitude of wave motions, the two simplest being so-called Langmuir waves and ion-sound waves. In Langmuir waves, the ions are nearly stationary and the electrons rapidly oscillate around them like pendulums. The force that swings the electrons back and forth isn't gravity, however, but the strong electric field that temporarily builds up when the negative charge in the local cloud, or "blob," of electrons doesn't balance the positive charge in the ions. Hence the oscillations, as the disturbed electrons rush back to short out the field, overshoot, and rush back again. The lower-frequency ion-sound waves behave something like the sound waves in neutral gas, with one crucial twist. The waves' speed is now determined by the ion's inertia and the combined pressure of both species. In this wave, the ions and electrons swing in synchrony, held together by the electric field that comes about when one or



ION-SOUND PLASMA. A wave packet in the D-III tokamak system propagates and disperses near its plasma edge. (Courtesy of General Electric Co.)